Demonstration of Rich Reagent Injection in Ameren's Sioux Unit 1

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Discussion Outline

- What is Rich Reagent Injection (RRI)?
- Pre-Demonstration Results
- Demonstration Host Sites
- Model Based RRI Design – Sioux Unit 1
- Sioux Unit 1 Field Test Summary
- Summary

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Rich Reagent Injection (RRI)

- Process
  - » Injection of amine reagents into hot, fuel rich, NOx containing flue gases
- Performance
  - » Measured NOx reductions up to 90% in pilot scale furnace
  - » Mixing limitations limit performance in full scale boilers
  - » No NH_3 slip
- Key Parameters
  - » Temperature, local stoichiometry, NSR, residence time
- Commercial Status
  - » 2nd full scale demonstration complete
  - » Technology has been sublicensed to two system suppliers

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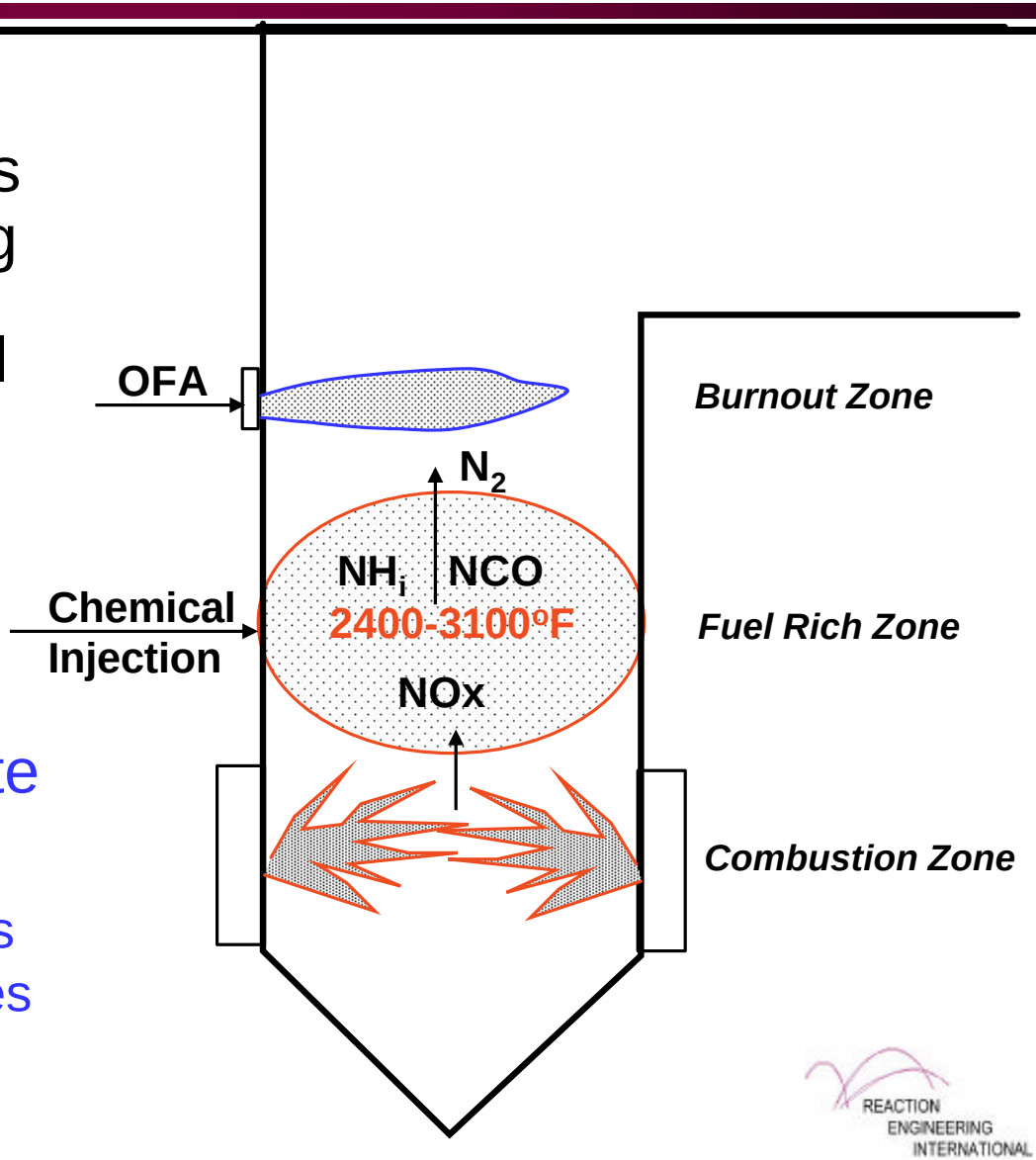
RRI in Cyclone Fired Furnaces

- Significant NOx reductions achievable with air staging
- Staging creates a hot, fuel rich lower furnace
  - » In-situ reburning
  - » Increased NOx reduction with reduced SR and increased residence time
- Amine reagents accelerate the rate of NOx reduction
  - » NOx reduction in rich zones
  - » NOx formation in lean zones



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Pre-Demonstration Evaluations

- Detailed chemical kinetic modeling (CKM)
- Bench and Pilot scale testing
- CFD model development
- CFD analysis in full-scale cyclone-fired boilers

High Probability for Successful Full Scale Demonstrations

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Demonstration Sites

- Small Unit
  - Conectiv's B.L. England Unit 1
  - 130 MW, 3 cyclone barrels, front wall fired, OFA
  - Existing 3-zone SNCR hardware
  - 8 RRI ports/injectors installed for testing
  - Results reported last year

- Large Unit
  - AmerenUE's Sioux Unit 1
  - 500 MW, 10 cyclone barrels, opposed wall fired
  - OFA installed mid 2001

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AmerenUE's Sioux Plant

- Two Units – Nominal Rating of 500 MW each
- Supercritical
- 10 cyclone barrels, 5 each on front & rear walls
- Common Windbox
- 85% to 50% PRB blend with Illinois bituminous, petcoke, and TDF
- First application of OFA in cyclone unit was in Unit 2

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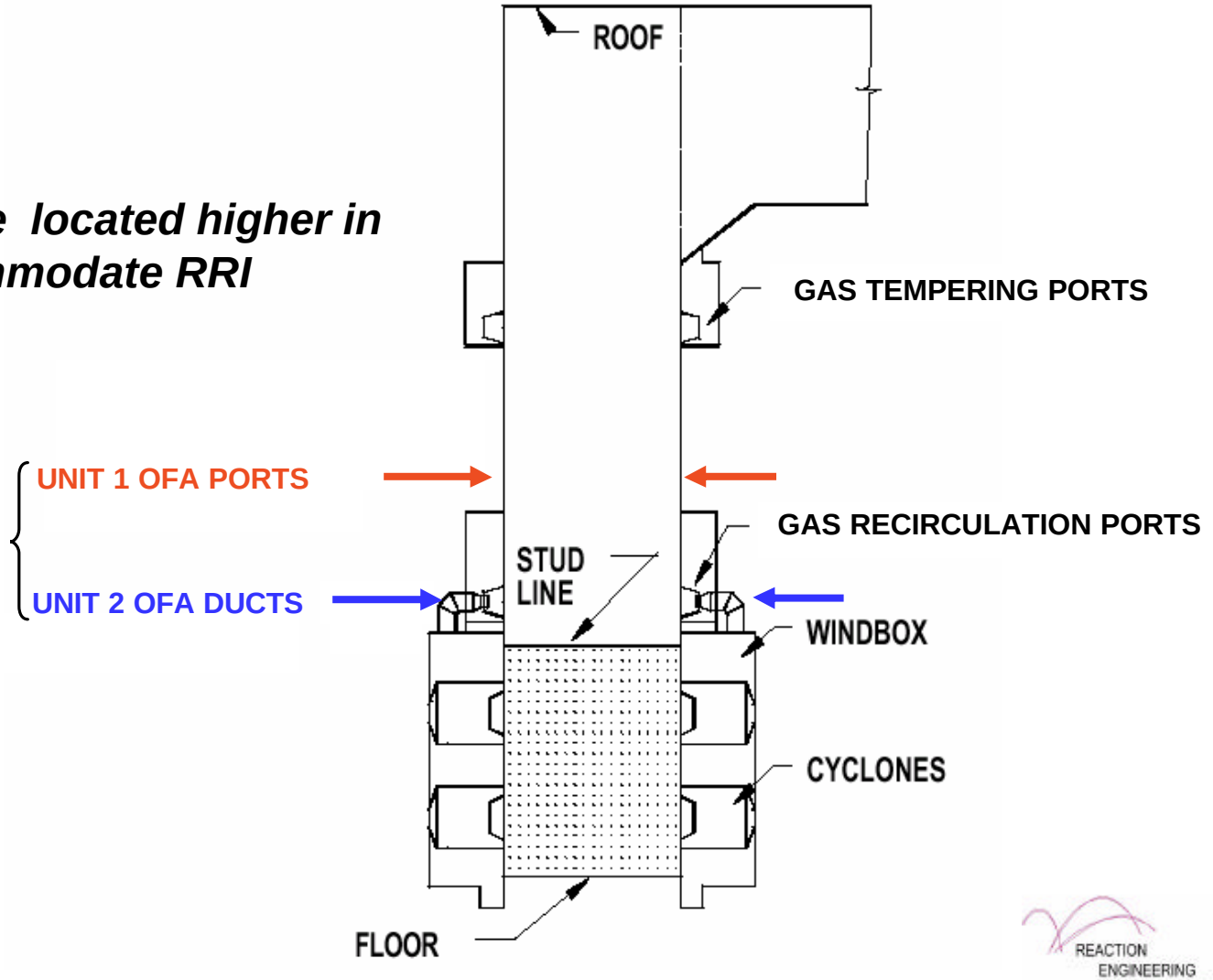
Sioux Boiler Section

OFA Ports were located higher in Unit 1 to accommodate RRI



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RRI Injection Design
Sioux Unit 1

- Utilize CFD modeling to evaluate impacts of:
  - » Nozzle locations
  - » Injector parameters
  - » Boiler operation (e.g. stoichiometry, FGR operation)

- Account for existing structural and equipment interferences with proposed injector locations
  - » Windbox and FGR penetrations
  - » Hot gases, running slag

- Keep project costs low

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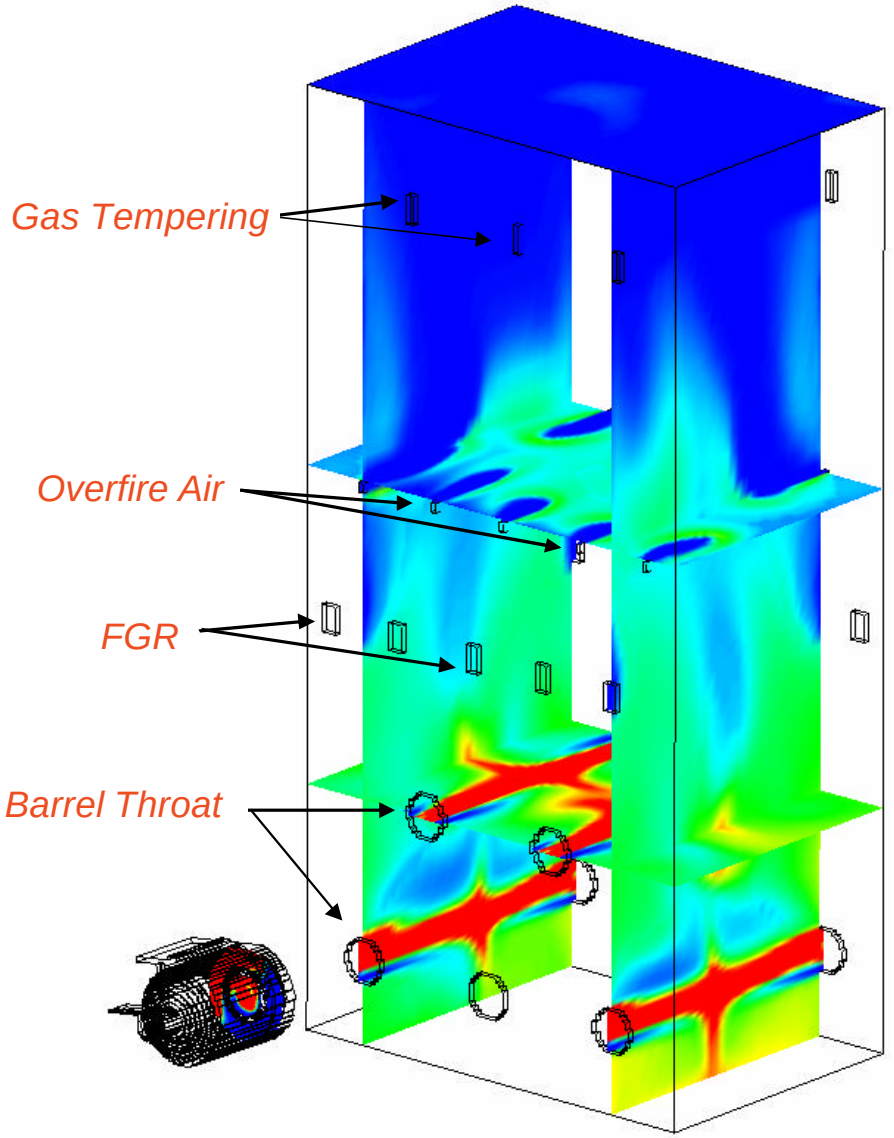
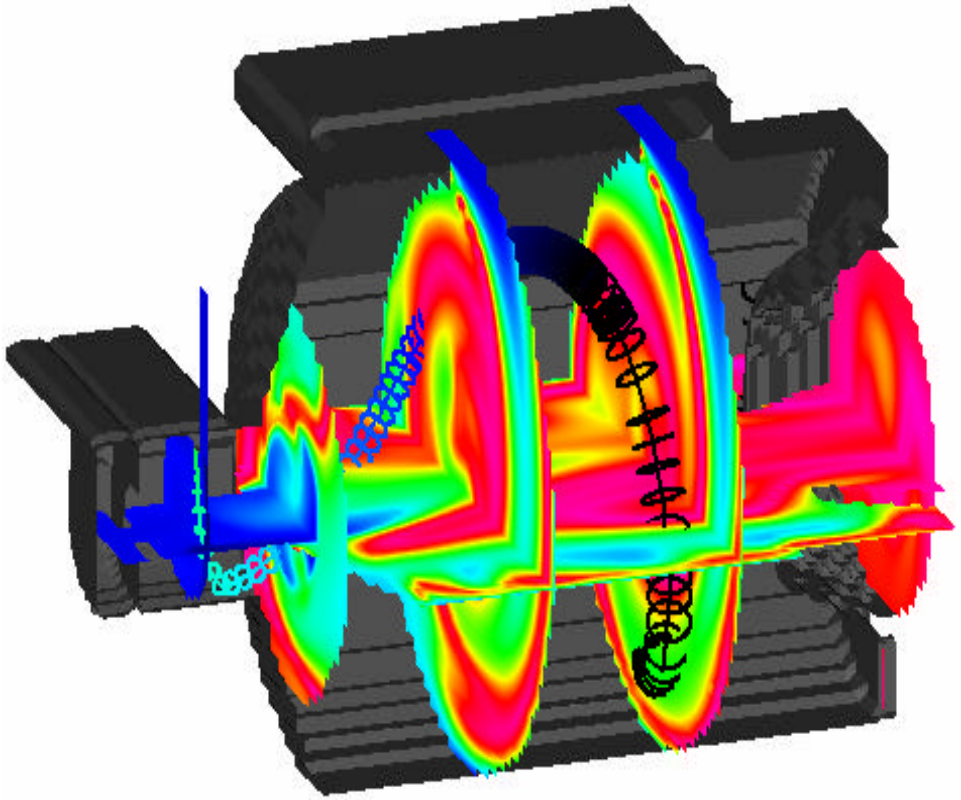
CFD Model Approach

- Cyclone Barrel
- Lower Furnace OFA
- Lower Furnace OFA + RRI



Sioux Cyclone Barrel Modeling

- Barrel model developed through CNCIG team
- Predictions verified against measurements
- Very fuel rich regions near walls, except near secondary air duct
- Flow predicted to be very segregated



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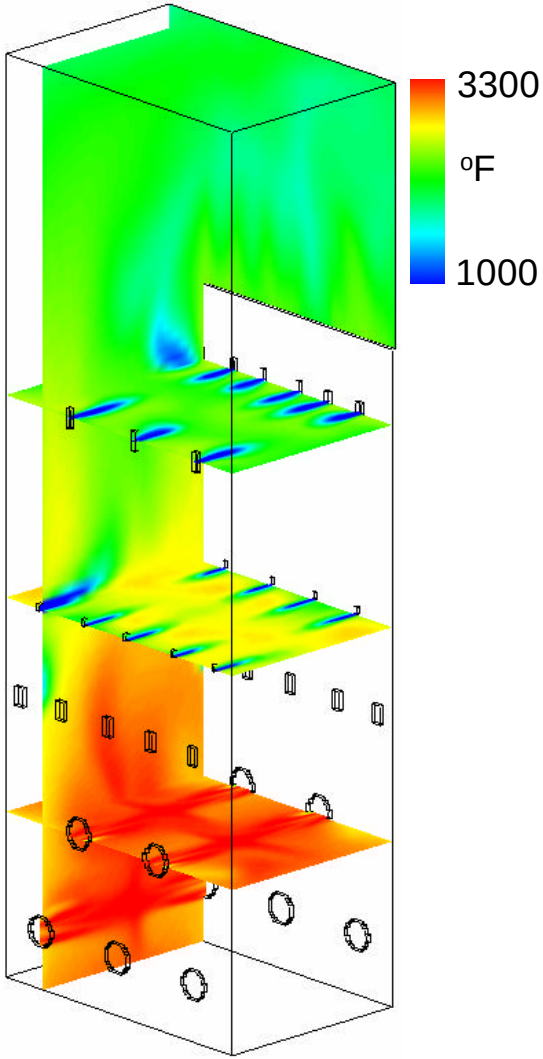
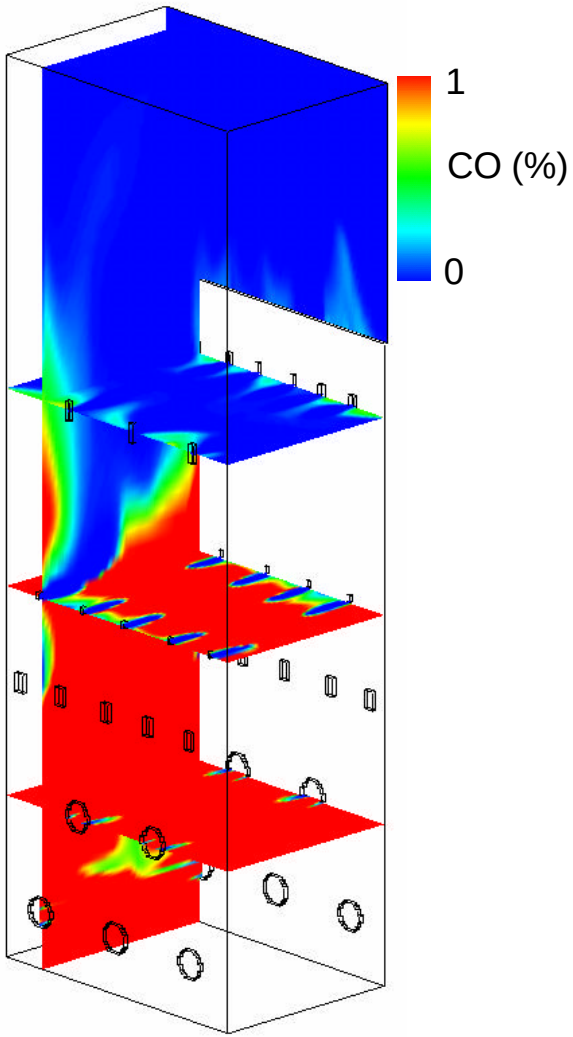
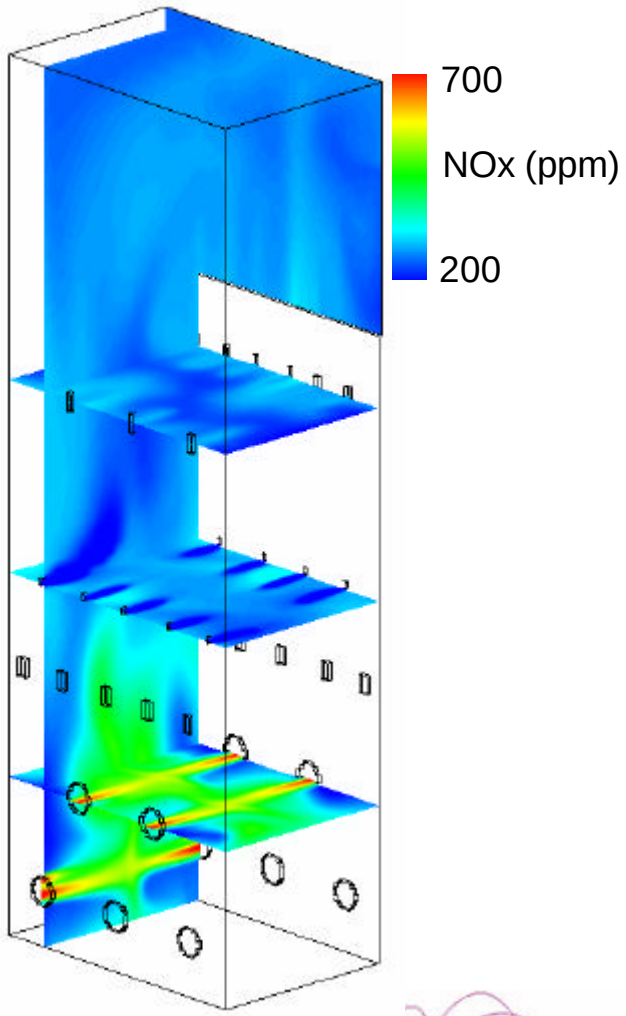
Sioux Unit 1 OFA Modeling

"As Built" OFA







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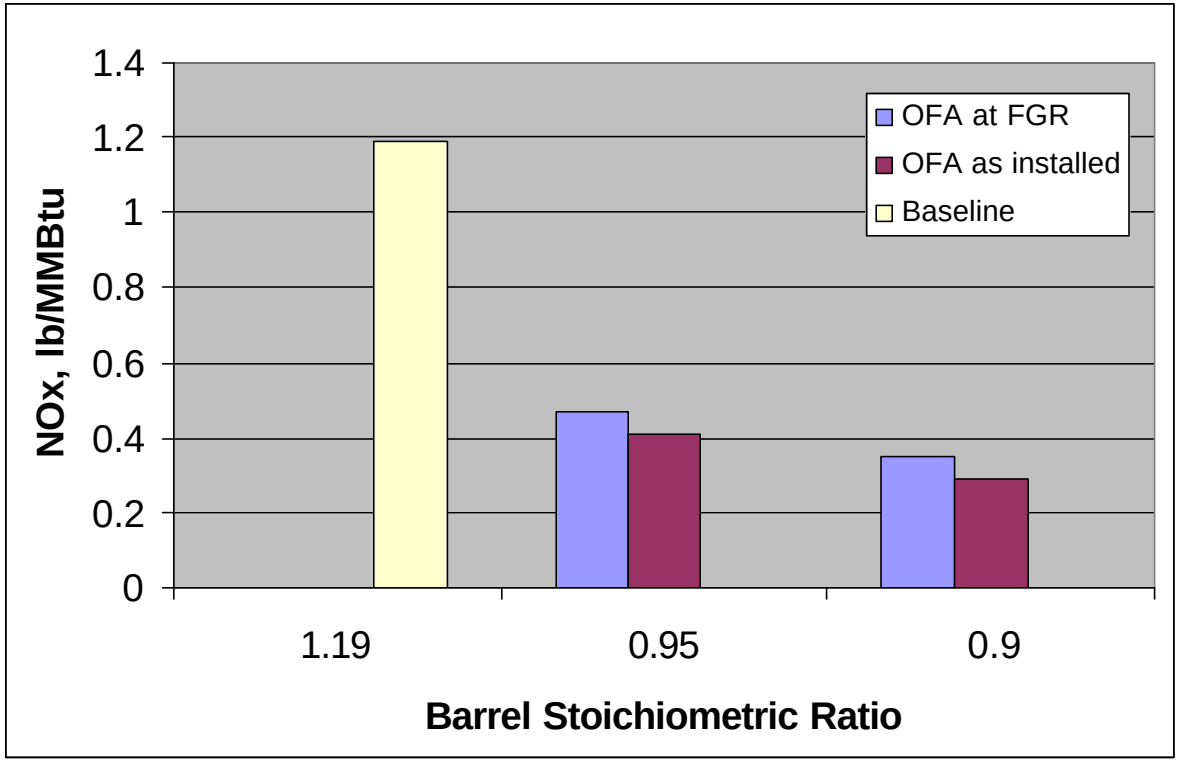
Predicted NOx Emissions

Sioux Unit 1 OFA

- At least 65% NOx reduction predicted at SR=0.95
- Small predicted increase in NOx reduction by raising OFA elevation
- NOx emissions of 0.30 lb/MMBtu predicted for SR=0.90
- Less than 100 ppm increase in predicted furnace exit CO



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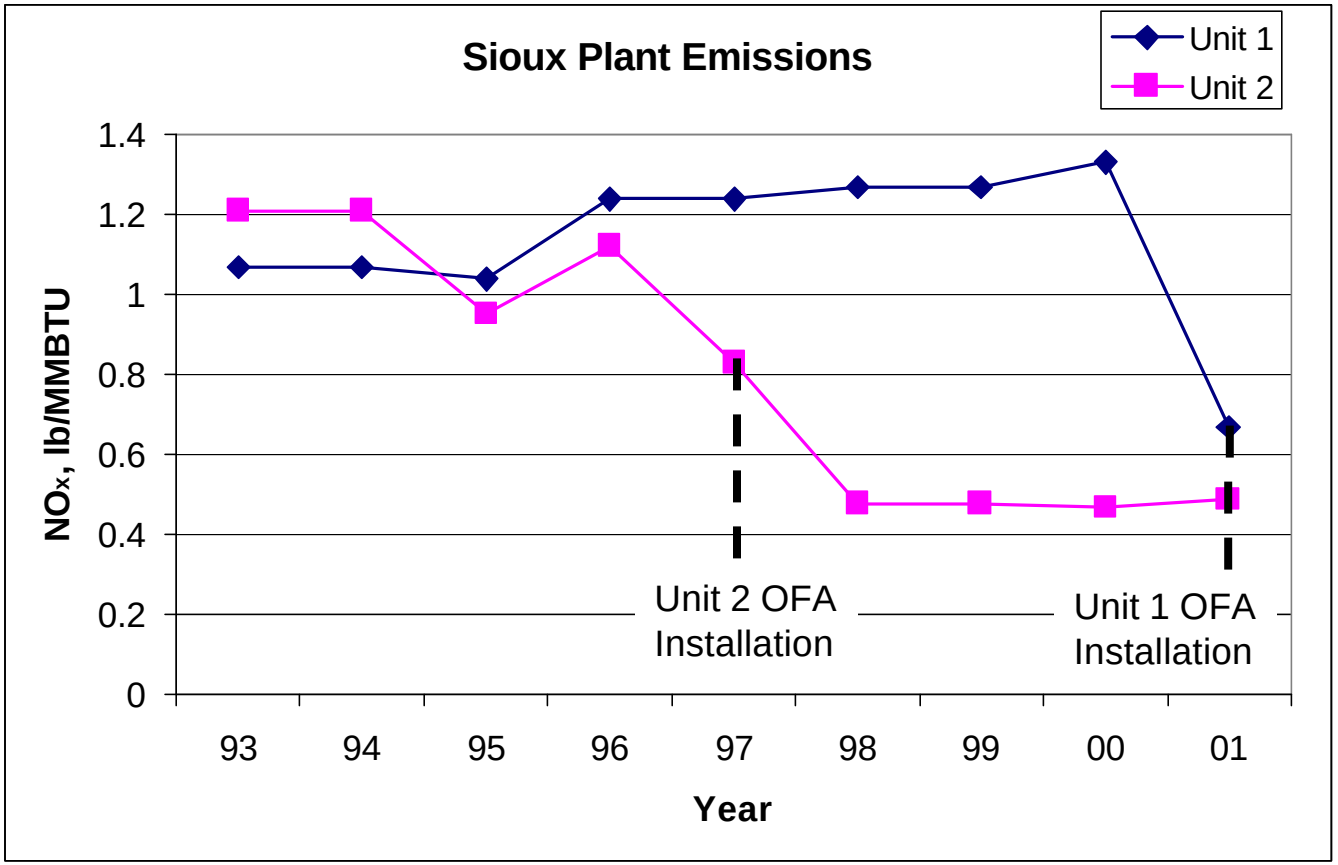
Sioux Plant NOx Emissions

Annual Averages



Sioux plant NOx emissions following OFA installation have confirmed model predictions

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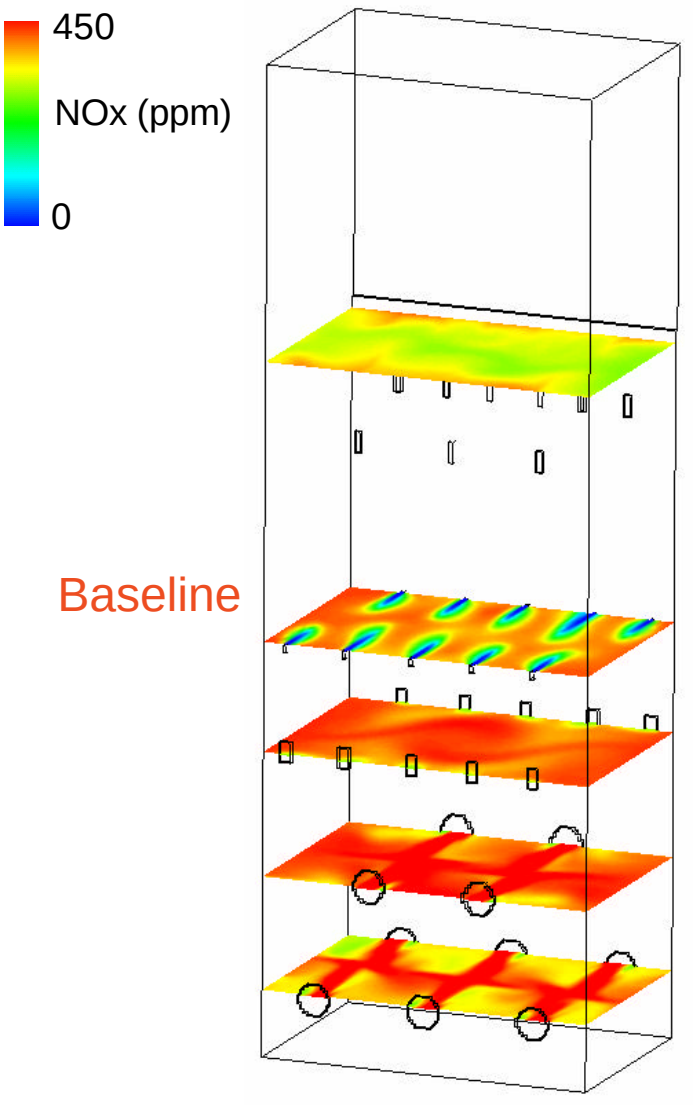
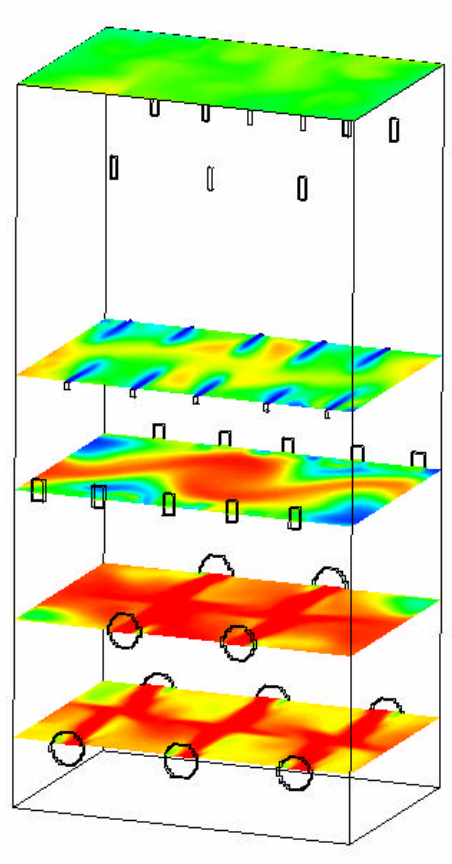
Sioux Unit 1 RRI Modeling

NOx Distribution





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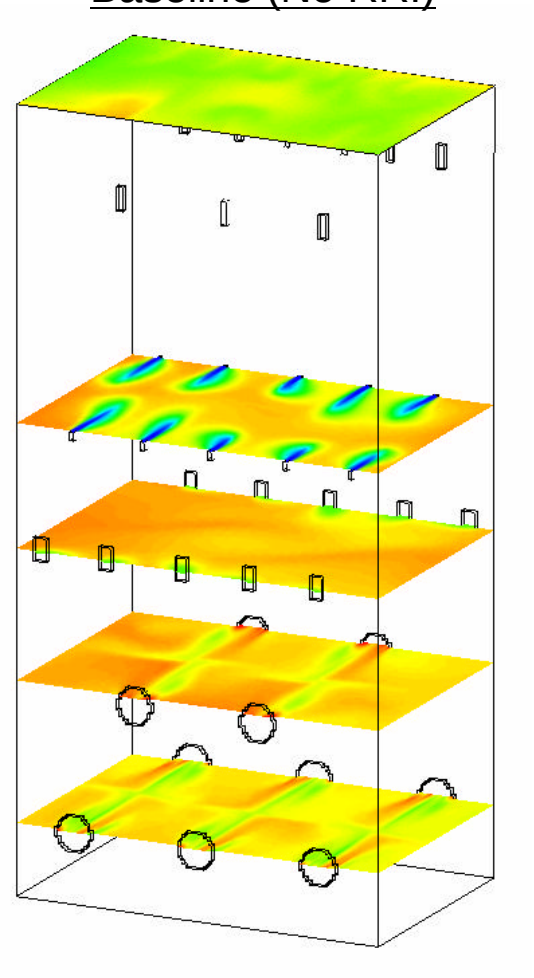
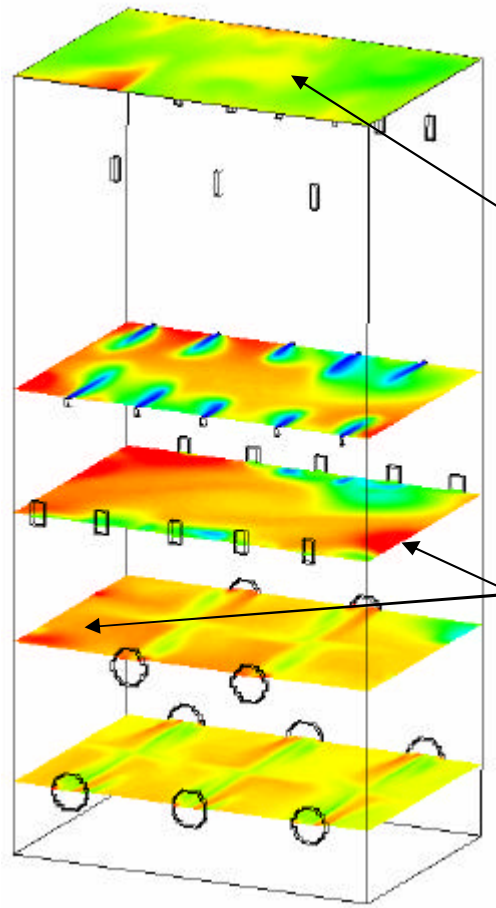
Predicted Impact of SR on RRI
Sioux Unit 1

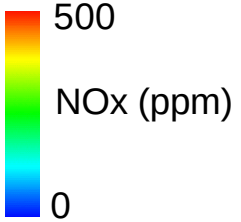
Lower Furnace SR = 0.99

Baseline (No RRI)



RRI





No net NOx reduction

Localized NOx Increases due to Increased O_2

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CFD Modeling Summary
Sioux Unit 1

- 20 RRI ports installed
  - » 6 on each side wall
  - » 4 each on front and rear walls

- 30-35% NOx reduction with RRI (SR=0.95)
  - » NSR = 2.8 (based on 0.41 lb/MMBtu)
  - » No ammonia slip
  - » 0.28 lb/MMBtu from baseline of 0.41 lb/MMBtu

- Negligible NOx reduction for near stoichiometric lower furnace (SR=0.99) utilizing design injection

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Sioux Unit 1 RRI Demo

Typical Reagent Injector with Reagent and Air Supplies

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Sioux Unit 1 RRI Demo

Temporary Reagent Storage Tank with Delivery Truck

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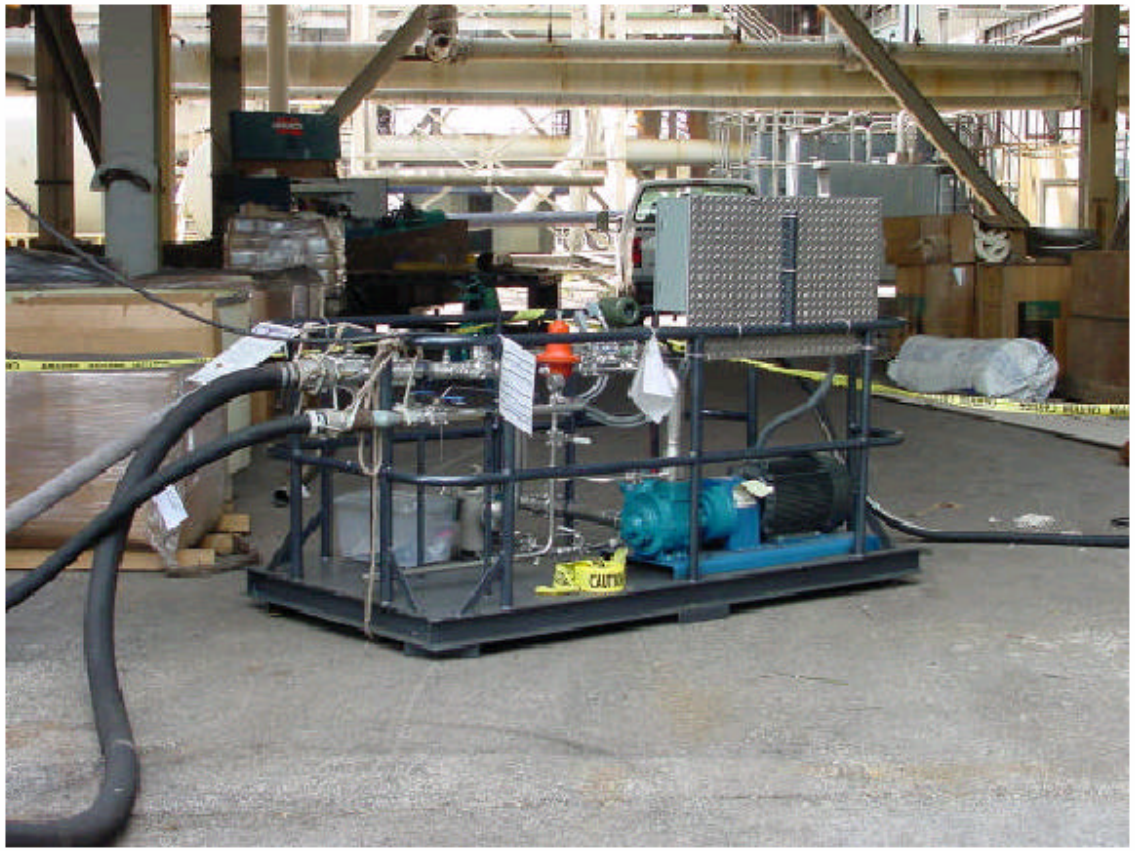
Sioux Unit 1 RRI Demo

Reagent Transfer Pump Skid



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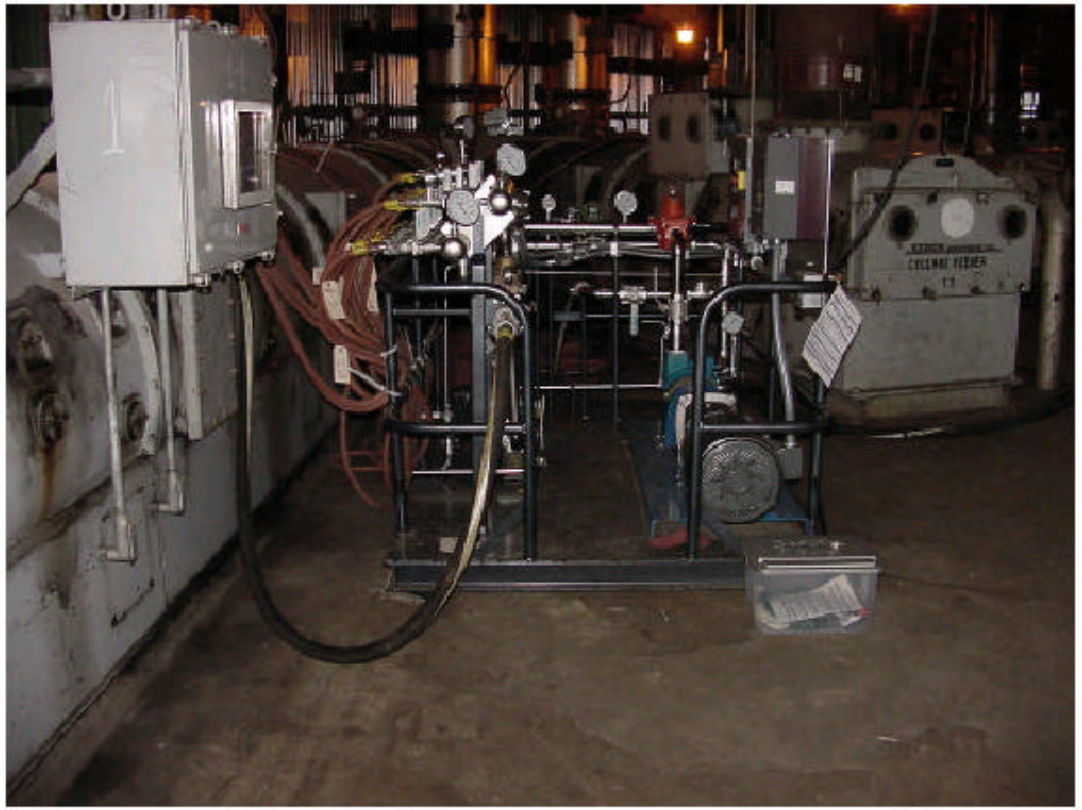
Sioux Unit 1 RRI Demo

Injection Pump Skid, Each Supplying 10 Injectors



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Sioux Unit 1 RRI Demo

Damaged Injection Nozzle

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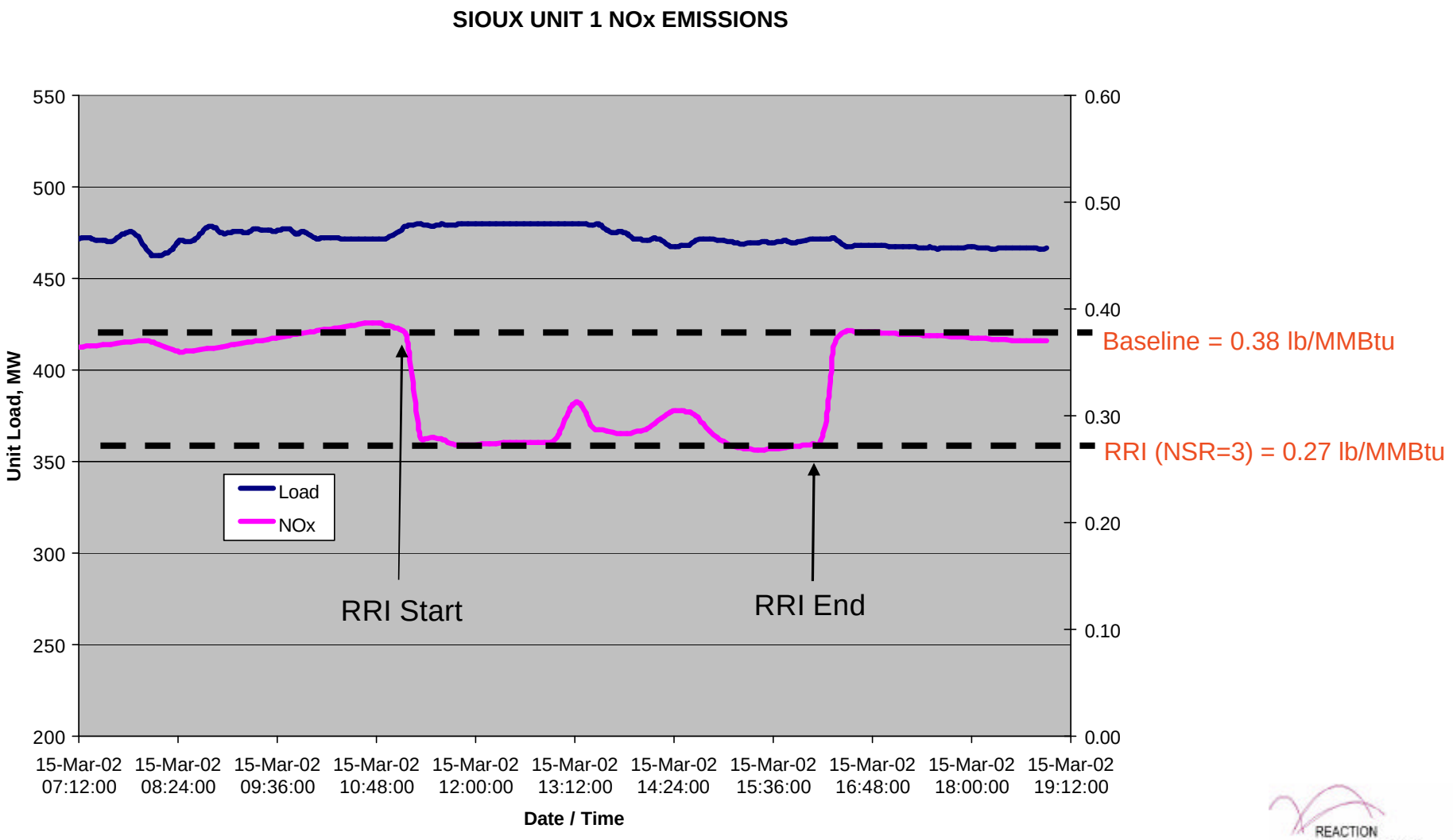
Sioux 1 RRI Testing
Typical Results



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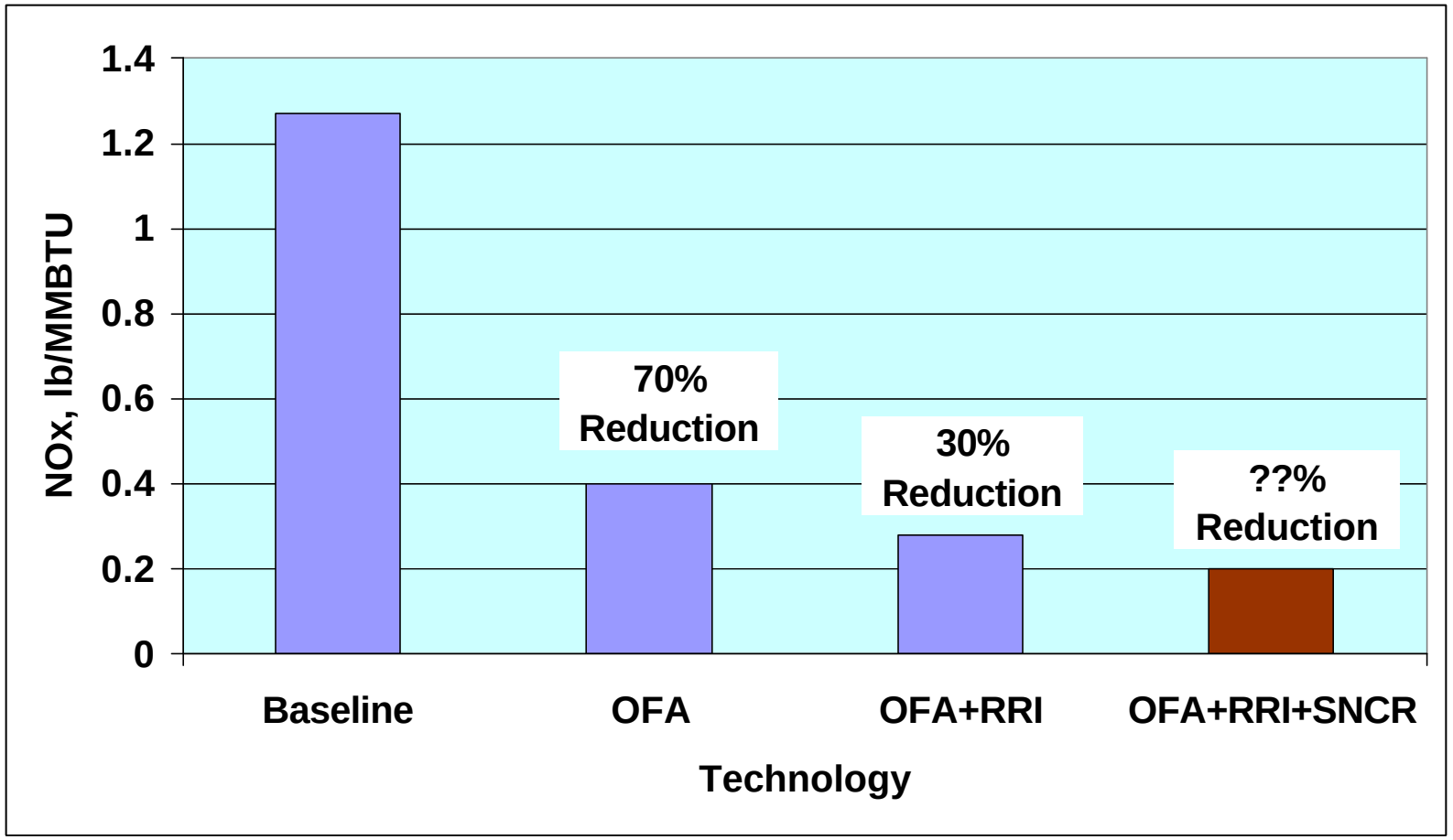
Demonstrated NOx Reductions

Sioux Unit 1



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Summary

- Two completed RRI demos show that RRI is capable of achieving 30% NOx reduction (beyond reductions with OFA) in staged cyclone fired boilers
- NH_3 sampling showed <1 ppm NH_3 slip during RRI testing in both demo units
- CFD model predictions have been consistent with field test results and are critical part of the RRI design
- Operating costs for RRI are expected to be 2-3 times that of SNCR due to increased reagent usage

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Thank You!

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